Feedback from physical activity monitors is not compatible with current recommendations: A recalibration study

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Abstract

Wearable devices to self-monitor physical activity have become popular with individuals and healthcare practitioners as a route to the prevention of chronic disease. It is not currently possible to reconcile feedback from these devices with activity recommendations because the guidelines refer to the amount of activity required on top of normal lifestyle activities (e.g., 150 minutes of moderate-to-vigorous intensity activity per week over-and-above normal moderate-to-vigorous lifestyle activities). The aim of this study was to recalibrate the feedback from self-monitoring.

We pooled data from four studies conducted between 2006 and 2014 in patients and volunteers from the community that included both sophisticated measures of physical activity and 10-year risk for cardiovascular disease and type 2 diabetes (n=305). We determined the amount of moderate-to-vigorous intensity activity that corresponded to FAO/WHO/UNU guidance for a required PAL of 1.75 (Total Energy Expenditure/Basal Metabolic Rate).

Our results show that, at the UK median PAL, total moderate-to-vigorous intensity physical activity will be around 735 minutes per week (~11% of waking time). We estimate that a 4% increase in moderate-to-vigorous intensity activity will achieve standardised guidance from FAO/WHO/UNU and will require ~1000 minutes of moderate-to-vigorous intensity activity per week.

This study demonstrates that feedback from sophisticated wearable devices is incompatible with current physical activity recommendations. Without adjustment, people will erroneously form the view that they are exceeding recommendations by several fold. A more appropriate target from self-monitoring that accounts for normal moderate-to-vigorous lifestyle activities is ~1000 minutes per week, which represents ~15% of waking time.

Key words: Physical activity status, physical activity recommendations, physical activity monitoring, physical activity energy expenditure, exercise.

Highlights

- Many people are self-monitoring their physical activity in a way that was impossible in the past.
- Current physical activity guidelines were not formulated with such technology in mind.
- Our study shows that self-monitoring is not compatible with current activity guidelines.
- An adjusted target for self-monitoring is ~ 1000 minutes of activity per week (~15% of waking time).

BACKGROUND

There has been an explosion in the availability of wearable devices that allow people to self-monitor and track their physical activity [1]. Wearable technologies are enormously popular and it is estimated that in 2016 alone global sales will approach 100 million units [2]. Thus, there are millions of people around the world who are beginning to self-monitor their physical activity in a way that was never possible in the past.

These wearable technologies are a potentially very useful way for individuals to self-monitor and manage their physical activity as a route to the prevention of chronic disease [3 4]. In addition, as the accuracy and affordability of these technologies has improved, they are beginning to play an increasingly important role in healthcare and public health [1].

Based on our previous research [3 5 6], we suspected that many people will receive feedback from physical activity monitoring that is difficult to reconcile with recommended levels of physical activity from national agencies (e.g., The Department of Health in the UK, [7]). The public as well as healthcare providers need to be equipped with an understanding of the output from these devices if they are to be used successfully to help support and/or monitor behaviour.

The purpose of the present investigation was to clarify and recalibrate physical activity feedback from wearable technologies in order to reconcile differences with physical activity recommendations and thus provide guidance to help the public and healthcare practitioners interpret this potentially valuable information.

METHODS

Design

To ensure that this research was not prone to either device- or population-specific influences, we combined data from studies that used two very different devices for the collection of physical activity data and that also targeted different populations (including both the general public and patients recruited from primary care). We collated data from several studies that were conducted at the University of Bath between 2006 and 2014. In all studies, sophisticated measures of physical activity were employed to characterise participants and other measures were also included to enable the calculation of cardiovascular and type 2 diabetes risk (QRISK and/or QDiabetes score). One analysis draws on studies that recruited men from the local community and used an expensive research-grade instrument for the assessment of physical activity energy expenditure (Comparison 1). The second analysis comes from a study that recruited patients from primary care and employed a commercially-available physical activity monitor (Comparison 2). A key feature of this analysis is that the instruments used in both comparisons derive accurate estimates of physical activity in units of energy expenditure (kJ/min). Participants in all studies provided written informed consent.

Comparison 1: Research-based physical activity monitor

For comparison 1, we examined our previous projects to identify studies where we had both physical activity data and risk of cardiovascular disease and type 2 diabetes in middle-aged participants from the local community. We identified three studies and pooled these data to undertake the present comparison [8-10]. The device employed to collect physical activity energy expenditure in these studies was a research instrument that uses synchronized accelerometry and heart rate with branched equation modelling (Actiheart, Cambridge Neurotechnology Ltd., Cambridge, UK) and has been shown to have excellent accuracy [11-14]. Each device costs around £1000 ($1500 US) and it is unlikely that this specific instrument will ever be sold directly to the public. However, given the rate of technological progress, commercially-available wearable technologies will be likely to perform at a similar level in the near future.

In all three studies for comparison 1, participants were recruited from the local community via advertisement (National Health Service Research Ethics Committee reference numbers 06/Q2001/30, 06/Q2001/105, and 11/SW/0193). Participants were non-smoking men who were not taking any medication and were aged 35 to 64 years (Table 1). In two studies (n=66), participants were only included if they self-reported low participation in structured exercise (i.e., two or fewer occasions of structured exercise lasting 30 minutes per week). One study recruited a sub-group of highly active volunteers who self-reported participation in at least 30 minutes of moderate intensity physical activity per day plus vigorous intensity exercise at least 3 times per week (n=12). In the remaining volunteers (n=23), no specific physical activity or exercise inclusion criteria were employed.

Comparison 2: Commercially-available physical activity monitor

For comparison 2, we undertook an analysis of physical activity data from patients recruited from primary care in the South West of the UK as part of the Mi-PACT trial (National Health Service REC reference number 13/SW/0179). The men and women in this study were recruited based on having moderate-to-high risk of cardiovascular disease or type 2 diabetes according to records in GP databases. The physical activity data were collected with a physical activity monitor that is already being sold and used widely by the public (BodyMedia FIT, BodyMedia Inc., Pittsburgh, PA). Importantly, unlike many other commercially-available devices, it is possible to extract raw minute-by-minute estimates of energy expenditure in order to undertake the necessary data processing to extract the key physical activity metrics required for our analysis (SenseWear® Pro 8.0, algorithm v5.2). Although this technology is available to the public as a commercial product, it has also been used in research studies and has excellent reported accuracy [15-20].

The sample for this comparison represents the first 204 sequential patients who were screened as part of the Mi-PACT study [21]. Briefly, this study recruited men and women from primary care aged 40-70 years at medium (≥10 and <20%) or high (≥20%) risk of cardiovascular disease and/or type II diabetes mellitus (based on QRISK or QDiabetes scores calculated from records in their GP's notes). People were excluded with existing

coronary heart disease, chronic kidney disease (stages 3-5), diabetes mellitus, stroke, heart failure and peripheral arterial disease. Participant characteristics are shown in Table 1.

Physical Activity Energy Expenditure: Data Handling and Analysis

Both physical activity instruments used in the current analysis are body mounted and collect data on a minute-by-minute basis (day and night). Weekly physical activity energy expenditure records for both comparisons were exported to Excel and processed in exactly the same way. To be included, physical activity data was required for at least 90% of a full 7-day period. Missing data were allocated estimated energy expenditure equivalent to basal metabolic rate [22]. We determined Physical Activity Level (PAL) as the product of Total Energy Expenditure/Basal Metabolic Rate [6] and time engaged in moderate intensity activity (> 3 Metabolic Equivalents or METs) and vigorous intensity activity (> 6 METs), where one MET represents resting metabolic rate. The primary analysis focuses on total accumulated physical activity data – the supplementary section online includes an analysis using bouts of activity greater than 10 minutes (Additional File 3).

QRISK and QDiabetes

We used age, sex, ethnicity, smoking status, cholesterol/HDL ratio, systolic blood pressure and body mass index to estimate QRISK and QDiabetes scores for each participant using the combined QIntervention platform [23].

Data analysis

Statistical analysis was conducted in 2015. We used simple linear regression to determine the average amount of physical activity per week above 3 METs associated with a PAL of 1.75 – the level of physical activity recommended by the FAO/WHO/UNU [24]. This model was applied to comparisons 1 and 2, separately, and to a pooled data set of all 305 participants. For simplicity, no study or participant characteristics were included in the models; this decision made no material difference to the estimates. Also, in the pooled model alone, we determined the amount of activity that an individual person would need to accumulate such

that the probability that their true PAL was ≥1.75 was at least 95% ("very likely";[25]). Using the standard error of the estimate obtained by regressing PAL on minutes per week >3 METS, we derived the minutes per week necessary for the lower limit of the 90% individual prediction interval for PAL to be 1.75. Applying a reference Bayesian approach, if the lower limit of the 90% confidence interval is 1.75 then the probability that this individual's true PAL is ≥1.75 is 95% (area to the right of 1.75 = 0.95).

RESULTS

As shown in Table 1, participants spent the majority of the time (~9000 minutes per week) engaged in activities below the moderate-to-vigorous intensity threshold of 3 METs (i.e., they spent most of their time engaged in sedentary activities, light intensity activities and sleep).

Table 1

Participant Characteristics

	Comparison 1 **Research Instrument** (n=101)	Comparison 2 **Commercial Instrument** (n=204)
Age, y	51 (6)	64 (6)
Male Sex N (% sample)	101 (100)	134 (66)
Height, m	1.79 (0.06)	1.71 (0.09)
Weight, kg	88 (12)	84 (15)
BMI, kg/m^2	27.5 (3.1)	28.7 (4.5)
Waist Circumference, cm	95.7 (10.4)	99.3 (11.1)
Systolic Blood Pressure, mm Hg	132 (15)	132 (17)
Diastolic Blood Pressure, mm Hg	87 (11)	87 (11)
TC/HDL Cholesterol	4.20 (0.92)	3.92 (1.11)
QRisk, %	5.3 (2.7)	14.2 (6.4)
QDiabetes, %	5.5 (3.2)	12.7 (9.1)
Low Risk, N (% sample)	81 (80)	13 (6)
Moderate Risk, N (% sample)	20 (20)	129 (63)
High Risk, N (% sample)	0 (0)	62 (30)
PAL, TEE/RMR	1.74 (0.20)	1.77 (0.25)
< 3 METs, minutes/wk	9228 (386)	8990 (571)
> 3 METs, minutes/wk	852 (386)	1090 (571)
> 6 METs, minutes/wk	65 (83)	109 (148)
On body time, %	96 (3)	99 (1)

TC: Total Cholesterol, PAL: Physical Activity Level, TEE: Total Energy Expenditure, RMR: Resting Metabolic Rate.

Moderate-to-vigorous intensity physical activity (comparison 1 and 2)

Total weekly moderate-to-vigorous intensity physical activity was 852 ± 386 minutes for comparison 1 and 1090 ± 571 minutes for comparison 2 (Table 1). Thus, in spite of using different devices and different populations, the accumulated total amount of moderate-to-vigorous intensity physical activity as a proportion of the week was broadly similar across the two comparisons. It is noteworthy that every person in the present study recorded more than 150 minutes of moderate-to-vigorous intensity physical activity per week. The full dataset is available in the supplementary section online (Additional files 1 and 2).

The relationship between standardised physical activity energy expenditure in the form of PAL and the amount of time spent engaged in moderate-to-vigorous physical activity is shown in Figure 1. Using these regression equations, a PAL of 1.75 as advocated by FAO/WHO/UNU equates to 861 and 1052 minutes of moderate-to-vigorous physical activity for comparisons 1 and 2, respectively.

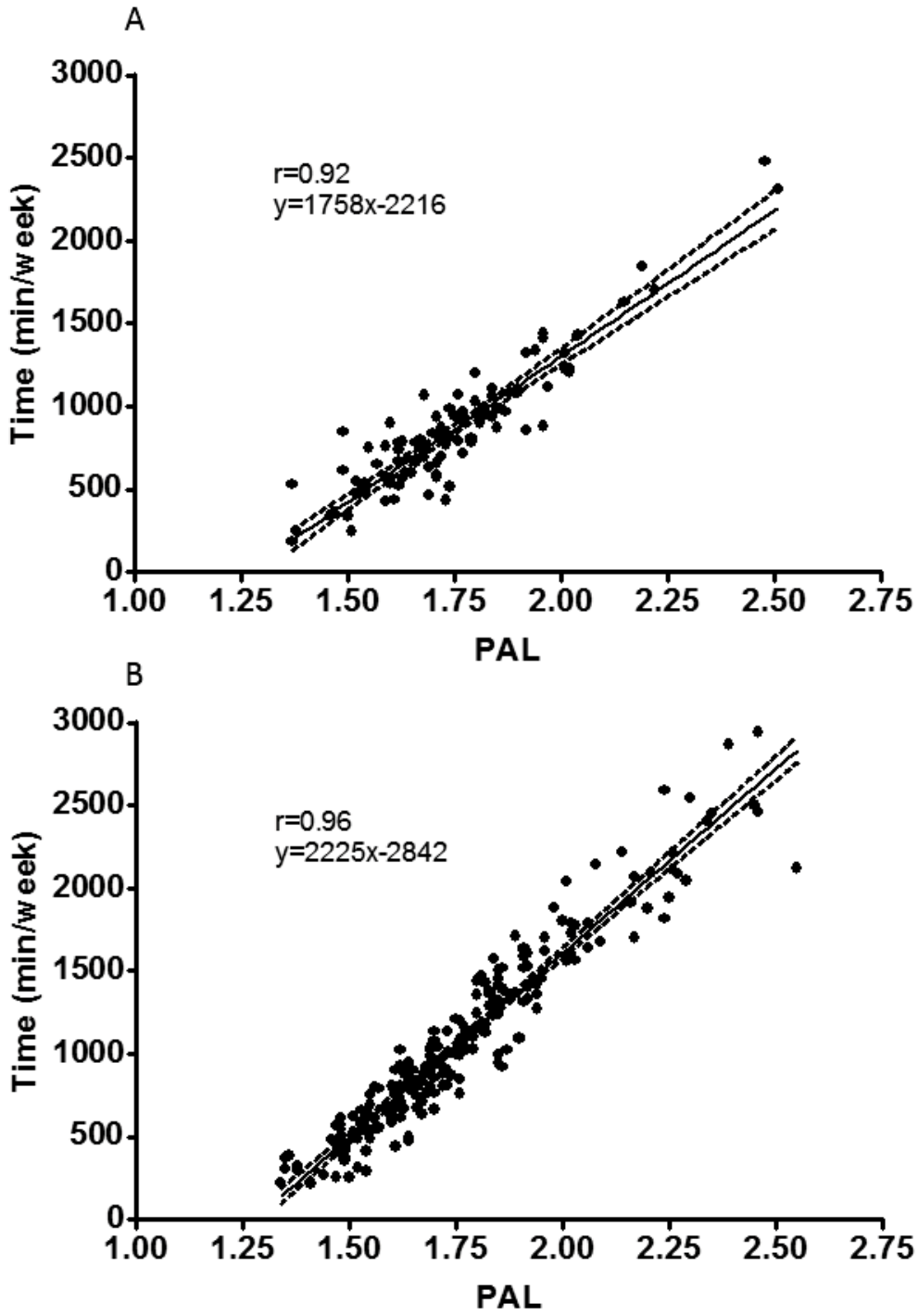

Figure 1

The relationship between PAL as a standardised measure of physical activity energy expenditure (TEE/BMR) and time engaged in moderate-to-vigorous intensity physical activity. Panel A shows the research instrument used in Comparison 1 (n=101) and Panel B the commercial instrument used in Comparison 2 (n=204). Data was collected between 2006 and 2014. The regression line with 95% CI are included. Inspection of residuals plots revealed no problems with model specification, other than one substantial outlier in comparison 2, with a negative standardised residual >4 standard deviations from the mean. A sensitivity analysis revealed that removal of this case made no material difference to the findings, so we elected to retain it in the analyses.

Moderate-to-vigorous intensity physical activity (merged across both comparisons)

We merged the data for both comparisons to determine the relationship between standardised physical activity energy expenditure in the form of PAL and the amount of time engaged in moderate-to-vigorous intensity physical activity (Figure 2; n=305). A comprehensive assessment of energy expenditure in the UK calculated median PAL to be 1.63 and this is used as the basis for current UK energy requirements [26]. Based on our analysis shown in Figure 2, we estimate that an increase from the UK median PAL of 1.63 to a PAL of 1.75 as advocated by FAOWHO/UNU would require an increase in moderate-to-vigorous physical activity of 4% of waking time assuming a 16 h waking day (i.e., from 11% to 15% of total waking time). For someone at the UK median PAL, this would require an increase in moderate-to-vigorous intensity physical activity of around 255 minutes per week on top of existing physical activity.

To put this into context given our focus on self-monitoring using wearable devices, we estimate that the *total* amount of moderate-to-vigorous intensity activity required to achieve a PAL of 1.75 is 990 minutes per week based on our merged analysis across both comparisons (95% confidence interval for the predicted mean, 969 to 1012 minutes).

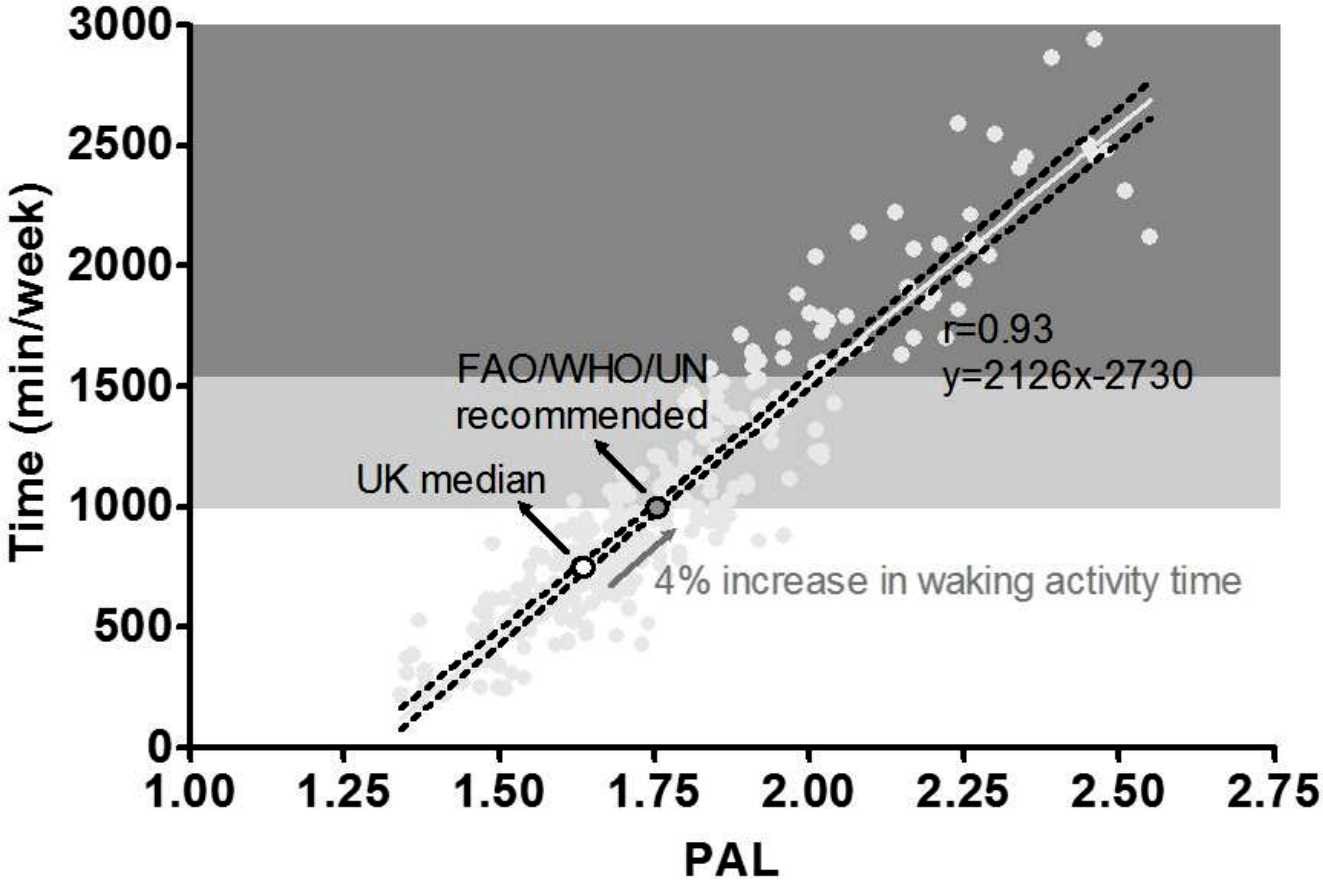

Figure 2

The relationship between PAL and time engaged in moderate-to-vigorous intensity physical activity merged across both comparisons (n=305). Data was collected between 2006 and 2014. The UK median PAL is displayed (1.63) in addition to the FAO/WHO/UN recommended PAL of 1.75. The light grey and dark grey shaded areas depict ranges for 'moderately active' and 'vigorously active' lifestyles as set out by FAO/WHO/UN [24].

The standard error of the estimate in predicting PAL from minutes per week of moderate to vigorous physical activity was 0.08 units. The amount of moderate-to-vigorous intensity activity associated with a lower limit of the 90% individual prediction interval for a PAL of 1.75 was 1330 minutes per week: point estimate for PAL = 1.89 (90% individual prediction interval 1.75 to 2.03). Thus, for a 95% probability that an individual's true PAL is ≥1.75 requires an accumulated total of 1330 minutes of moderate-to-vigorous physical activity per week.

DISCUSSION

Our results demonstrate that data from accurate physical activity monitoring produces a picture that is incompatible with the 150 minute per week target disseminated via national public-facing websites [27]. Instead, when using such devices, a more appropriate target is ~1000 minutes of moderate-to-vigorous intensity physical activity per week.

In this study, we show that average moderate-to-vigorous intensity physical activity from sophisticated self-monitoring is 5 to 7-fold greater than the 150-minute per week target advocated by key healthcare agencies [27-29]. This finding is robust and consistent across two different populations and using two different devices. The reason for this mismatch is because the 150-minute target was originally proposed to be on top of 'baseline' physical activity, which is defined as 'normal lifestyle activities' [30 31]. As previously discussed by Powell *et al*., this concept has been rather soft and poorly characterised in the past because of the limited evidence that was available at the time [30]. Perhaps as a result of this uncertainty, the reference to 'on top of baseline' is usually omitted from wider dissemination aimed at the public [27-29]. This means that the perceived target for weekly physical activity has become 150 minutes, which is reasonable until people start using sophisticated instruments that capture ALL their physical activity (i.e., including baseline normal moderate-to-vigorous lifestyle activities). Our analysis anchors the output from sophisticated technologies to thresholds from the FAO/WHO/UN [24 32], and will help avoid confusion by the public and healthcare professionals.

The median PAL in the UK is 1.63 [26] and this is not hugely different to the median PAL across both comparisons reported in the present study (1.72). Thus, these observations are not because we have somehow recruited an unrepresentative sample. In this context, it is noteworthy that recent large observational studies in hundreds of participants from across Europe and North America demonstrate that weekly moderate-to-vigorous intensity physical activity is 600-1200 minutes when assessed using sophisticated research instruments [5 6 17 33-35]. It is particularly noteworthy that every person in the present study, even those with a very low PAL (e.g., <1.39), exceeded 150 minutes of accumulated moderate-to-vigorous intensity physical activity per week. This mismatch is important because most commercially available

devices report the sum of accumulated moderate-to-vigorous intensity physical activity as the primary feedback. Thus, self-monitoring with sophisticated physical activity monitors will not provide a picture that is compatible with current physical activity recommendations.

We have previously proposed that the output from technological innovation in physical activity monitoring will require recalibration if viewed in the context of physical activity recommendations [5 6]. Our current analysis goes some way towards achieving this goal. We show that, for someone at the UK median PAL, moderate-to-vigorous intensity activity will be around 735 minutes per week (equivalent to ~11% of waking time, assuming 8 hours of sleep). This approximates typical 'baseline' moderate-to-vigorous intensity activity; and a 4% increase in waking moderate-to-vigorous intensity activity would be required to shift PAL to the level recommended by the FAO/WHO/UN (Figure 2). Our derived relationship is entirely consistent with an independent analysis from the Institute of Medicine (IOM) [36]. The IOM estimated that to increase PAL from their defined sedentary level of 1.39 to their low active category of 1.60 would require an increase in daily moderate-to-vigorous intensity physical activity of 60 minutes per day. Our estimate, based on the relationship shown in Figure 2, would require a remarkably similar increase of 64 minutes per day (i.e., to increase PAL from 1.39 to 1.60). Thus, after factoring in normal 'baseline' lifestyle activities, it appears that approximately 1000 minutes of moderate-to-vigorous intensity physical activity per week corresponds to standardised guidance from the FAO/WHO/UN [24 32]. This may initially seem like a large amount of activity, but it only represents ~15% of weekly waking time (with the remaining 85% distributed across sedentary and light intensity activities). This does not mean that people need to start doing 1000 minutes of 'new' moderate-to-vigorous intensity activity – instead, it represents the sum of all activities after accounting for normal moderate-to-vigorous lifestyle activities.

Our results indicate that whilst 150 minutes of activity a week is a useful way to convey the change required at population level because it is inevitably a prescription above 'baseline' normal moderate-to-vigorous lifestyle activities, this target will not tally with the picture an individual receives from self-monitoring because this approach inevitably captures these normal moderate-to-vigorous lifestyle activities. Thus, if a patient or healthcare practitioner uses information from self-monitoring and consults widely disseminated physical activity

guidance then they will form an erroneous view of their physical activity status (i.e., they are likely to erroneously conclude that their activity is several fold higher than the guidance). Future iterations of physical activity guidelines should either reflect *all* physical activity (i.e., including normal lifestyle activities) or there should be separate guidance for use in conjunction with sophisticated wearable physical activity monitors.

Physical activity guidelines sometimes refer to 'sustained' participation in moderate-to-vigorous intensity physical activity undertaken in bouts of 10 minutes or more [7]. This is often lost in wider dissemination where there is no reference to bouts (e.g., [27]). The concept of a 10-minute period for physical activity accumulation is largely arbitrary [6 37] and bouts of less than 10 minutes are demonstrably very positive for various health outcomes [38 39]. It is therefore unsurprising that most technology companies have chosen not to build 'bouts' into their platforms. Whilst bouts have low relevance to the current analysis because few commercial self-monitoring devices provide this feedback, readers can find an analysis of these data in the supplementary section online (Additional File 3).

Our findings will apply to devices and technologies with a similar accuracy and precision to the instruments that were used in the present study. The multi-sensor devices that we used have excellent validity when compared to doubly-labeled water and/or to criterion measures of energy expenditure in the laboratory [11-14 15-20]. The quality of the output from these devices is quite different to simple accelerometry. This is an important consideration given the rate of technological development – particularly amongst the commercial sector. This is a very rapidly evolving field with tens of millions of devices being sold to consumers and huge investment from global businesses. These commercial instruments are becoming more-and-more sophisticated and include integrated heart rate monitors, gyrometers, heat and galvanic skin sensors (etc.) in order to improve the accuracy of estimated energy expenditure. It is noteworthy that the multi-sensor instrument from Bodymedia that we used is already classified by the US Food and Drug Administration (FDA) as a Class II medical device. There was a modest difference between estimates of time engaged in at least moderate intensity activity between comparisons 1 and 2 (~13% and 16% of an estimated waking week,

respectively). To explore this issue, we examined the effect of age on the differences in the estimates between devices, via an age*device interaction term. A 10-year increment in age decreased the difference in the estimates between devices by 72 minutes (95% CI, 5 to 139 minutes). We regard this as a trivial interaction effect in the face of a mean (SD) for moderate-to-vigorous intensity physical activity overall of 1011 (529) minutes. No other study characteristic, including wear time, substantially influenced the difference between estimates. It appears therefore that the small difference in the estimates might be due to device-specific measurement differences. Importantly, the overall conclusions from the current study are strengthened by the finding that two different multi-sensor devices that capture energy expenditure in distinctive ways and are worn in different body locations produced similar overall estimates of moderate-to-vigorous intensity physical activity.

There will inevitably be some specific considerations that could affect any comparison with the current analysis, such as the threshold used for moderate intensity physical activity. We have used an absolute threshold of 3 METs since this includes most forms of walking [40] and is ubiquitous amongst most physical activity guidelines [6]. Whilst it would be theoretically possible to shift this MET threshold upwards to reduce the amount of reported activity to a level closer to 150 minutes a week, it would be inappropriate to meddle with what is meant by moderate intensity physical activity to try and force a fit with existing recommendations. We should also highlight that these findings will also only apply when the wear time is as high as reported in the present study, in contrast to surveys that often report a minimum wear time for a valid day of only 10 hours [41 42]. Wear time in most research studies is rarely as high as reported here but we believe that this will become more commonplace as devices become more comfortable to wear or are body mounted. A further consideration is that we have focussed on one single physical activity outcome (moderate-to-vigorous intensity activity), but other dimensions are also demonstrably important [3]. Future recommendations should take into account the other physical activity dimensions to provide a more complete and holistic view of an individual's physical activity since we do not all have to do the same thing to obtain the health benefits of physical activity [3]. However, for the key issue of feedback on moderate-to-vigorous intensity physical activity, which is likely to feature in future

recommendations as well as information from self-monitoring, our analysis helps interpret the output from wearable devices.

Conclusions

The emergence of affordable wearable technologies to enable the self-monitoring of physical activity has created many exciting opportunities. However, without adjustment, feedback from accurate physical activity monitors is not compatible with widely disseminated physical activity guidance (i.e., the recommendation to accumulate 150 minutes per week of moderate-to-vigorous intensity activity). After taking into account normal moderate-to-vigorous lifestyle activities, an appropriate weekly target is approximately 1000 minutes of moderate-to-vigorous intensity (equivalent to ~15% of weekly waking time).

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Authors' Contributions

DT conceived the study and drafted the manuscript and is the guarantor. AMB participated in the design of the study and undertook data analysis. OJP participated in the design of the study and collected/collated data. MW collected physical activity data. RB participated in the design of the study and collected clinical data. All authors contributed to the drafting of the manuscript and approved the final version.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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COMPARISON 1														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
1	M	48	1.80	88.0	27.3	3.7	4.0	1870	3445	1231	344	1.84	92	9144	936	9	275	0
2	M	54	1.93	104.7	28.0	5.7	6.6	2070	3645	1210	365	1.76	90	9008	1072	7	269	0
3	M	62	1.78	95.1	29.9	11.2	11.1	1722	2774	775	277	1.61	91	9643	437	24	76	10
4	M	55	1.81	101.2	30.9	7.4	10.6	2033	3275	914	328	1.61	95	9644	436	0	142	0
5	M	55	1.83	78.6	23.4	5.9	2.7	1789	2921	839	292	1.63	94	9294	786	63	202	0
6	M	57	1.87	96.7	27.7	7.4	6.8	1670	2677	739	268	1.60	98	9527	553	37	132	0
7	M	57	1.76	76.3	24.7	7.6	3.6	1755	3199	1124	320	1.82	90	9128	952	10	433	0
8	M	47	1.83	97.6	29.3	4.2	5.6	2007	4097	1680	410	2.04	91	8650	1430	20	240	0
9	M	45	1.77	91.8	29.2	3.0	5.0	1925	3657	1366	366	1.90	91	8995	1085	45	355	44
10	M	54	1.78	85.1	27.0	5.2	5.1	1858	3652	1428	365	1.97	91	8961	1119	10	468	0
11	M	51	1.77	90.5	28.8	4.7	6.3	1938	3622	1321	362	1.87	96	9113	967	43	333	0
12	M	54	1.81	87.8	26.9	6.1	5.1	1903	3464	1215	346	1.82	94	9135	945	13	135	0
13	M	46	1.81	107.1	32.7	3.3	9.3	2132	4283	1723	428	2.01	95	8855	1225	37	285	14
14	M	56	1.79	92.8	29.1	6.2	8.2	1934	2905	680	291	1.50	92	9742	338	18	90	15
15	M	60	1.74	78.2	25.8	10.2	5.1	1786	2669	616	267	1.49	96	9234	846	11	168	0
16	M	54	1.87	100.5	28.8	5.5	7.4	2037	3993	1557	399	1.96	97	8670	1410	7	401	0
17	M	58	1.80	89.5	27.6	8.0	7.0	1909	3297	1058	330	1.73	98	9650	430	6	78	0
18	M	53	1.80	87.4	27.0	4.2	4.9	1871	2845	1171	284	1.52	94	9531	549	18	140	0
19	M	50	1.90	85.5	23.8	3.8	2.1	1881	2755	599	276	1.46	92	9741	339	21	49	0
20	M	47	1.76	86.0	27.6	4.2	4.2	1847	2780	655	278	1.51	91	9835	245	7	0	0
21	M	58	1.78	94.3	29.9	7.6	9.7	1953	3318	1033	332	1.70	92	9239	841	33	200	0
22	M	62	1.83	89.6	26.8	11.1	6.6	1643	2661	695	266	1.62	91	9409	671	5	124	0
23	M	52	1.75	91.1	29.7	7.8	7.9	1894	3500	1256	350	1.85	98	9211	869	321	408	260
24	M	52	1.86	112.1	32.4	5.2	11.8	2157	3508	1000	351	1.63	95	9512	568	34	153	21
25	M	59	1.73	88.2	29.5	7.9	9.5	1880	3042	858	304	1.62	97	9342	738	49	346	10
26	M	53	1.75	83.9	27.3	6.1	5.5	1834	3249	1090	325	1.77	97	9114	966	47	282	0
27	M	51	1.80	108.4	33.5	6.4	12.9	2107	4094	1578	409	1.94	100	8745	1335	8	380	0
28	M	53	1.70	90.6	31.3	5.6	10.9	1923	3436	1169	344	1.79	97	9295	785	10	277	0
29	M	46	1.79	91.8	28.7	3.7	4.7	1913	3871	1571	387	2.02	95	8875	1205	3	431	0
30	M	61	1.77	71.8	22.9	10.0	3.0	1453	2530	824	253	1.74	93	9094	986	23	387	0
31	M	52	1.69	68.2	24.0	5.3	2.5	1666	2867	914	287	1.72	93	9381	699	3	130	0
32	M	49	1.77	96.6	30.8	4.8	8.4	1978	3879	1513	388	1.96	97	8638	1442	4	474	0
33	M	51	1.75	86.5	28.4	4.7	6.0	1856	3629	1410	363	1.96	94	9202	878	28	221	0
34	M	48	1.79	102.2	31.9	3.5	9.1	2037	3128	778	313	1.54	97	9594	486	10	35	0
35	M	55	1.90	88.7	24.6	5.6	3.4	1906	3403	1157	340	1.79	94	9271	809	32	239	0
36	M	61	1.73	82.4	27.5	10.8	7.1	1551	2829	994	283	1.82	93	9085	995	49	336	11
37	M	54	1.80	83.7	25.8	6.2	4.3	1834	3188	1035	319	1.74	96	9564	516	9	110	0
38	M	50	1.84	96.6	28.5	4.2	5.9	1965	3779	1436	378	1.92	92	8754	1326	71	513	50
39	M	46	1.95	129.9	34.2	3.8	11.4	2361	3823	1078	382	1.62	92	9299	781	27	274	0
40	M	47	1.64	88.6	32.9	4.2	10.4	1898	3505	1256	350	1.85	91	9097	983	15	310	0
41	M	61	1.76	90.8	29.3	8.6	10.0	1649	2264	635	226	1.37	98	9552	528	13	62	0
42	M	50	1.96	103.0	26.8	4.1	4.2	2050	3574	1167	357	1.74	97	9265	815	28	140	0
43	M	56	1.86	93.0	27.0	8.2	5.6	1956	3445	1145	345	1.76	96	9287	793	94	345	86
44	M	50	1.87	95.3	27.3	4.1	4.5	1985	3684	1330	368	1.86	99	9095	985	7	341	0

COMPARISON 1														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
45	M	45	1.82	97.3	29.4	2.7	4.9	1994	3126	820	313	1.57	95	9431	649	7	184	0
46	M	52	1.88	102.4	29.0	4.6	6.8	2052	3179	809	318	1.55	97	9332	748	14	206	0
47	M	50	1.77	71.7	23.0	4.3	1.8	1696	2696	731	270	1.59	98	9503	577	22	72	0
48	M	53	1.78	85.5	27.0	5.6	4.9	1847	3396	1211	340	1.84	97	9018	1062	6	243	0
49	M	57	1.76	72.0	23.2	10.0	2.8	1698	2608	650	261	1.54	96	9563	517	4	281	0
50	M	56	1.75	71.7	23.3	8.2	2.8	1698	3438	1396	344	2.02	98	8851	1229	10	344	0
51	M	55	1.75	77.7	25.5	7.1	4.0	1766	2891	836	289	1.64	99	9395	685	17	288	0
52	M	47	1.77	96.8	31.0	3.1	7.5	1984	3608	1263	361	1.82	96	9115	965	18	220	0
53	M	57	1.76	95.0	30.5	8.0	11.0	1961	3604	1283	360	1.84	98	8972	1108	19	342	0
54	M	55	1.74	89.6	29.6	8.4	8.9	1899	3078	871	308	1.62	97	9557	523	41	124	33
55	M	46	1.67	76.0	27.3	2.5	3.6	1743	3866	2122	387	2.22	98	8382	1698	131	835	36
56	M	45	1.89	85.0	23.8	2.0	1.6	1858	3169	1309	317	1.71	98	9145	935	192	405	33
57	M	57	1.83	77.0	23.0	5.4	2.6	1755	3002	1247	300	1.71	95	9495	585	156	395	150
58	M	57	1.77	80.0	25.5	6.6	4.5	1789	3437	1647	344	1.92	99	9221	859	231	353	187
59	M	61	1.72	63.0	21.3	7.7	2.2	1594	2647	1052	265	1.66	96	9301	779	237	404	166
60	M	47	1.82	83.0	25.1	2.3	2.4	1824	3151	1327	315	1.73	98	9310	770	214	410	161
61	M	46	1.78	78.0	24.6	1.9	2.0	1652	2931	1280	293	1.77	97	9362	718	241	323	233
62	M	49	1.79	77.5	24.2	3.7	2.3	1766	3027	3027	303	1.71	100	9507	573	245	338	239
63	M	59	1.82	89.0	26.9	9.4	6.1	1892	3023	1130	302	1.60	98	9180	900	123	277	37
64	M	56	1.79	86.0	26.8	8.1	5.5	1858	2857	999	286	1.54	96	9541	539	8	112	0
65	M	61	1.76	80.0	25.8	12.2	5.4	1523	2242	718	224	1.47	96	9721	359	2	0	0
66	M	48	1.74	104.0	34.4	5.1	12.8	2122	4038	1916	404	1.90	96	8977	1103	64	131	0
67	M	54	1.78	88.0	27.8	7.4	6.1	1973	3150	1177	315	1.60	97	9545	535	4	72	0
68	M	55	1.83	69.0	20.6	4.7	1.4	1663	3336	1673	334	2.01	99	8757	1323	86	449	19
69	M	56	1.81	87.0	26.6	7.8	5.2	1870	2973	1104	297	1.59	95	9654	426	6	92	0
70	M	59	1.80	80.0	24.7	9.4	4.0	1789	2731	941	273	1.53	97	9606	474	17	116	0
71	M	49	1.86	94.0	27.2	3.9	4.2	1950	3534	1231	353	1.81	96	9183	897	13	232	0
72	M	46	1.85	83.0	24.3	3.3	1.9	1824	2891	778	289	1.59	99	9322	758	28	636	0
73	M	54	1.80	85.0	26.2	6.5	4.5	1812	3179	1049	318	1.75	96	9135	945	32	373	10
74	M	56	1.80	101.0	31.2	8.5	11.5	2019	3410	1050	341	1.69	98	9616	464	3	24	0
75	M	59	1.76	83.0	26.8	11.0	6.8	1824	3116	981	297	1.71	97	9507	573	4	115	0
76	M	41	1.78	76.7	24.2	1.2	1.3	1716	2942	931	294	1.71	98	9425	655	130	241	106
77	M	52	1.69	80.2	28.1	5.9	5.8	1793	2459	420	246	1.37	97	9892	188	96	122	73
78	M	49	1.71	75.5	25.8	2.6	3.1	1718	3761	1666	376	2.19	96	8233	1847	176	889	54
79	M	47	1.75	78.9	25.7	2.8	2.8	1630	2889	970	289	1.77	93	9152	928	79	265	0
80	M	51	1.77	86.1	27.4	5.4	5.0	2086	3532	1093	353	1.69	96	9446	634	8	298	0
81	M	36	1.76	89.7	29.1	0.8	2.2	1924	4144	1806	414	2.15	100	8448	1632	280	786	169
82	M	48	1.90	109.1	30.2	3.5	7.0	1661	2932	978	293	1.77	99	9179	901	117	180	80
83	M	52	1.86	107.9	31.1	4.8	10.0	1845	2744	625	274	1.49	98	9466	614	22	299	0
84	M	49	1.82	99.6	30.2	3.6	7.4	1809	2742	658	274	1.52	96	9604	476	79	190	48
85	M	50	1.65	98.0	35.8	5.8	16.5	1997	3311	983	331	1.66	98	9399	681	126	253	105
86	M	38	1.79	75.0	23.5	0.7	0.8	1793	3367	1237	337	1.88	99	8999	1081	153	456	27
87	M	43	1.72	68.1	22.9	1.4	1.1	1499	3720	1849	372	2.48	98	7600	2480	303	1296	185
88	M	35	1.73	71.7	23.8	0.4	0.7	2082	3441	1015	344	1.65	96	9479	601	84	204	35

COMPARISON 1														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
89	M	50	1.86	85.0	24.7	5.0	2.6	1692	2845	869	285	1.68	95	9388	692	121	419	119
90	M	48	1.78	81.9	25.8	3.3	3.0	1654	2984	1032	298	1.80	97	9051	1029	118	494	54
91	M	47	1.87	76.0	21.9	2.1	1.2	1496	2571	818	257	1.72	95	9263	817	84	266	56
92	M	47	1.76	78.6	25.5	3.2	2.8	1554	2590	777	259	1.67	97	9332	748	155	340	89
93	M	54	1.72	73.6	24.9	4.3	3.5	1496	2513	766	251	1.68	98	9358	722	84	158	76
94	M	45	1.80	89.9	27.7	2.7	3.7	1606	2703	827	270	1.68	96	9015	1065	0	248	0
95	M	51	1.76	81.5	26.4	4.0	4.1	1573	2629	793	263	1.67	93	9337	743	274	384	168
96	M	35	1.78	111.6	35.2	1.2	6.2	2282	3800	1138	380	1.67	96	9282	798	41	103	14
97	M	41	1.84	97.5	28.9	1.7	3.2	2039	3517	1126	352	1.72	97	9211	869	62	331	23
98	M	44	1.95	114.0	29.9	2.8	5.3	2108	2902	503	290	1.38	93	9830	250	1	38	0
99	M	55	1.90	92.0	25.5	5.5	4.1	1704	2836	848	284	1.66	95	9414	666	73	183	18
100	M	44	1.73	81.5	27.2	4.0	3.0	1781	3203	1102	320	1.80	96	8880	1200	18	323	0
101	M	37	1.73	93.2	31.1	0.9	3.7	1859	4660	2335	466	2.51	99	7766	2314	370	1082	155
	Mean	51	1.79	88.4	27.5	5.3	5.5	1846	3220	1125	322	1.74	96	9228	852	65	287	34
	SD	6	0.06	11.7	3.1	2.7	3.2	176	473	402	47	0.20	3	386	386	83	209	62
	Min	35	1.64	63.0	20.6	0.4	0.7	1453	2242	420	224	1.37	90	7600	188	0	0	0
	Max	62	1.96	129.9	35.8	12.2	16.5	2361	4660	3027	466	2.51	100	9892	2480	370	1296	260

COMPARISON 2														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
1	M	68	1.76	96.4	31.1	18.1	22.6	1751	2790	1039	279	1.59	98	9394	686	56	413	10
2	M	67	1.63	73.2	27.7	17.0	9.3	1409	2838	1428	284	2.01	98	8040	2040	151	1733	55
3	M	43	1.74	108.8	35.9	3.6	10.0	2119	3572	1453	357	1.69	99	9094	986	3	620	0
4	F	61	1.63	99.0	37.3	8.3	15.2	1544	2758	1214	276	1.79	95	8945	1135	17	611	0
5	M	58	1.77	89.6	28.6	14.0	10.1	1899	3046	1147	305	1.60	99	9434	646	9	283	0
6	F	71	1.66	82.5	29.9	14.9	26.4	1428	2337	909	234	1.64	99	9225	855	32	562	0
7	F	51	1.62	88.5	33.7	8.2	24.7	1564	2428	864	243	1.55	100	9329	751	75	501	40
8	F	66	1.71	70.5	24.3	9.2	4.2	1354	2022	668	202	1.49	96	9723	357	4	178	0
9	F	69	1.59	81.5	32.2	11.6	23.6	1388	2237	849	224	1.61	99	9638	442	19	159	0
10	M	59	1.82	96.6	29.2	13.2	16.3	1979	3392	1413	339	1.71	99	9034	1046	142	826	70
11	M	63	1.74	74.0	24.6	12.2	4.6	1524	2838	1314	284	1.86	97	8561	1519	147	1100	21
12	M	66	1.82	87.4	26.4	14.6	6.7	1728	3899	2171	390	2.26	99	7968	2112	404	1614	30
13	M	65	1.71	69.9	23.9	14.6	4.1	1462	3018	1556	302	2.06	99	8292	1788	319	1425	121
14	M	69	1.73	91.2	30.6	19.8	27.8	1670	3151	1481	315	1.89	100	8369	1711	66	1376	0
15	F	58	1.66	102.1	37.1	5.5	15.3	1675	2787	1112	279	1.66	99	9277	803	11	308	0
16	M	68	1.76	78.5	25.3	23.9	6.2	1589	2195	607	220	1.38	99	9756	324	2	176	0
17	F	58	1.65	97.5	36.0	6.1	22.8	1637	2204	567	220	1.35	97	9774	306	1	152	0
18	F	56	1.59	84.0	33.1	3.5	16.2	1528	2465	937	246	1.61	98	9178	902	34	504	0
19	F	67	1.71	70.0	24.1	11.1	8.1	1350	2014	664	201	1.49	100	9660	420	7	231	0
20	F	58	1.66	86.0	31.4	6.6	15.5	1544	2557	1013	256	1.66	96	9333	747	15	363	0
21	F	64	1.70	123.7	43.1	7.5	34.0	1769	2733	964	273	1.54	99	9790	290	0	82	0
22	M	66	1.76	70.5	22.8	10.5	3.0	1516	2511	994	251	1.66	99	9247	833	56	515	11
23	M	71	1.78	82.7	26.1	27.0	13.0	1646	3328	1682	333	2.02	100	8478	1602	220	1194	15
24	M	62	1.72	70.9	24.0	9.7	3.5	1481	2207	726	221	1.49	100	9650	430	74	200	24
25	M	67	1.66	66.3	24.1	16.3	7.6	1381	3227	1846	323	2.34	99	7673	2407	500	1784	163
26	M	64	1.84	84.8	25.2	11.2	4.5	1719	2959	1240	296	1.72	99	9198	882	72	630	0
27	M	67	1.80	89.4	27.6	13.3	14.5	1727	2782	1055	278	1.61	99	9409	671	28	302	0
28	F	67	1.67	67.3	24.3	8.8	3.2	1310	2507	1197	251	1.91	99	8493	1587	105	1140	13
29	M	63	1.77	81.1	26.0	10.2	11.3	1617	2965	1348	297	1.83	99	8792	1288	99	870	0
30	F	62	1.67	74.0	26.5	7.9	7.5	1366	2168	802	217	1.59	98	9429	651	34	425	0
31	M	68	1.68	69.4	24.7	14.3	5.6	1424	2785	1362	279	1.96	97	8381	1699	175	1304	22
32	M	69	1.69	75.4	26.6	24.8	10.1	1488	3268	1781	327	2.20	99	8203	1877	263	1237	99
33	F	70	1.63	93.0	35.0	14.4	23.9	1497	2233	736	223	1.49	100	9702	378	19	124	0
34	M	60	1.98	112.8	28.8	14.0	7.5	2165	3829	1664	383	1.77	100	9038	1042	18	562	0
35	M	52	1.93	101.7	27.3	17.4	4.6	2037	3404	1367	340	1.67	100	9251	829	39	546	19
36	M	64	1.73	61.6	20.6	15.9	6.2	1406	2141	735	214	1.52	99	9592	488	124	316	60
37	M	69	1.78	82.0	25.9	16.6	6.5	1640	3336	1696	334	2.03	100	8513	1567	199	1255	99
38	M	62	1.76	107.3	34.8	12.4	18.2	1845	3110	1264	311	1.69	100	9054	1026	37	671	0
39	M	57	1.73	92.5	30.9	6.7	22.6	1932	3690	1758	369	1.91	98	8438	1642	60	1138	30
40	M	64	1.79	71.5	22.3	10.7	4.2	1554	3825	2271	383	2.46	98	7622	2458	808	1884	325
41	F	71	1.58	64.4	26.0	9.3	3.9	1246	3053	1807	305	2.45	99	7578	2502	638	1928	0
42	M	62	1.73	88.1	29.4	11.8	9.2	1647	3144	1497	314	1.91	99	8562	1518	21	945	0
43	F	71	1.57	73.8	30.1	14.0	18.5	1317	2059	743	206	1.56	100	9466	614	30	328	0
44	M	66	1.71	113.0	38.6	16.0	41.6	1853	3417	1564	342	1.84	99	8506	1574	2	802	0

COMPARISON 2														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
45	M	61	1.72	81.9	27.7	15.4	12.3	1581	2341	761	234	1.48	99	9466	614	87	413	0
46	M	70	1.78	92.2	29.1	18.8	17.5	1733	3504	1771	350	2.02	100	8292	1788	269	1556	120
47	F	66	1.66	83.0	30.1	8.7	10.2	1432	2524	1092	252	1.76	99	9232	848	6	397	0
48	F	64	1.56	80.4	33.0	10.4	16.3	1366	2233	867	223	1.63	99	9408	672	22	364	0
49	F	70	1.62	56.3	21.4	10.3	2.2	1205	2228	1023	223	1.85	100	9084	996	405	644	234
50	M	44	1.85	119.4	34.9	10.3	12.8	2241	5014	2773	501	2.24	99	7488	2592	28	2041	23
51	M	65	1.78	86.0	27.3	13.5	8.3	1671	2813	1141	281	1.68	98	9159	921	66	538	0
52	M	67	1.68	68.0	24.1	15.8	4.5	1416	3236	1821	324	2.29	99	8037	2043	575	1570	312
53	M	68	1.76	89.6	28.9	15.1	20.1	1689	3246	1556	325	1.92	99	8475	1605	21	1229	0
54	M	70	1.82	74.8	22.7	13.5	6.7	1609	3004	1395	300	1.87	99	9054	1026	119	715	10
55	M	59	1.74	65.6	21.6	7.2	2.5	1624	3643	2019	364	2.24	100	8261	1819	573	1455	226
56	M	64	1.81	89.0	27.3	24.8	17.2	1730	3105	1375	310	1.79	98	9053	1027	42	640	26
57	M	70	1.69	80.1	28.2	25.7	9.6	1530	2690	1160	269	1.76	97	8997	1083	132	737	26
58	M	57	1.80	95.5	29.5	17.2	13.1	1967	3479	1512	348	1.77	98	9062	1018	14	521	0
59	M	61	1.82	99.3	30.0	14.9	11.1	1836	4130	2295	413	2.25	100	8136	1944	82	1120	0
60	M	54	1.73	94.1	31.4	14.3	24.5	1951	3151	1200	315	1.62	98	9370	710	44	413	0
61	M	69	1.78	91.3	28.8	16.9	10.1	1724	3735	2011	374	2.17	98	8012	2068	194	1465	50
62	M	67	1.81	102.7	31.3	29.6	20.6	1857	2879	1022	288	1.55	99	9388	692	19	361	0
63	F	70	1.58	84.6	33.9	14.2	14.8	1408	2306	898	231	1.64	99	9606	474	28	237	0
64	F	68	1.65	76.5	28.1	13.2	11.3	1376	2153	777	215	1.56	99	9534	546	35	303	0
65	M	69	1.74	86.7	28.6	17.8	9.5	1644	2801	1157	280	1.70	100	9015	1065	115	844	0
66	M	63	1.84	84.3	24.8	11.9	3.9	1723	2831	1108	283	1.64	100	9235	845	10	699	0
67	F	69	1.61	54.6	21.0	12.4	2.6	1186	2382	1197	238	2.01	98	8520	1560	419	1198	217
68	F	70	1.64	89.3	33.4	12.3	18.6	1470	2741	1271	274	1.86	99	9161	919	10	372	0
69	F	60	1.68	60.9	21.5	8.2	1.8	1269	2346	1077	235	1.85	99	9136	944	220	510	60
70	M	70	1.73	81.3	27.2	20.5	10.8	1585	2739	1154	274	1.73	96	9271	809	22	411	0
71	M	66	1.77	74.1	23.8	11.9	4.2	1554	2781	1227	278	1.79	99	8976	1104	82	798	30
72	M	64	1.82	91.0	27.5	13.4	7.8	1760	2848	1088	285	1.62	98	9056	1024	42	633	0
73	M	64	1.78	97.2	30.7	9.7	10.9	1778	3259	1481	326	1.83	99	8719	1361	10	836	0
74	M	59	1.75	85.7	28.1	12.5	13.1	1854	4010	2155	401	2.16	99	8170	1910	285	1303	151
75	M	60	1.71	79.6	27.2	9.0	6.5	1492	3424	1932	342	2.30	99	7533	2547	170	1706	63
76	M	58	1.75	103.0	33.6	14.8	16.8	2053	3929	1876	393	1.91	99	8450	1630	87	1156	78
77	M	66	1.69	87.5	30.8	21.0	14.9	1598	2411	813	241	1.51	100	9559	521	12	245	0
78	M	63	1.80	85.5	26.4	11.8	6.3	1691	2588	897	259	1.53	97	9505	575	23	408	0
79	M	65	1.65	75.6	27.8	20.5	10.1	1455	3115	1660	312	2.14	98	7860	2220	242	1763	32
80	M	65	1.83	83.5	25.1	10.2	5.3	1697	2546	848	255	1.50	99	9826	254	70	92	69
81	F	71	1.69	76.4	26.8	12.4	5.4	1502	2726	1224	273	1.82	99	8649	1431	67	1016	0
82	M	52	1.72	93.8	31.7	24.3	15.6	1947	4058	2111	406	2.08	99	7937	2143	71	1712	0
83	M	66	1.70	71.5	24.7	16.3	11.2	1467	2966	1499	297	2.02	98	8351	1729	208	1267	45
84	M	65	1.63	65.2	24.5	29.6	7.5	1342	2960	1618	296	2.21	99	7990	2090	618	1818	329
85	M	62	1.70	73.2	25.5	7.8	4.8	1482	3102	1620	310	2.09	99	8405	1675	585	1315	542
86	M	69	1.82	96.6	29.2	20.9	10.9	1811	3064	1252	306	1.69	97	9138	942	7	501	0
87	F	71	1.57	61.0	24.9	15.3	7.0	1217	2317	1099	232	1.90	98	8990	1090	302	592	82
88	M	67	1.82	86.2	25.9	23.8	10.1	1717	3879	2163	388	2.26	99	7867	2213	308	1788	42

COMPARISON 2														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
89	F	65	1.61	72.1	28.0	7.0	5.7	1323	2196	873	220	1.66	98	9403	677	17	376	0
90	M	62	1.56	87.8	36.1	33.2	76.1	1479	2864	1385	286	1.94	100	8810	1270	157	991	0
91	F	69	1.58	53.8	21.5	11.3	7.5	1165	1827	661	183	1.57	99	9291	789	47	428	11
92	M	68	1.75	81.3	26.5	23.7	7.6	1604	2785	1181	279	1.74	98	9211	869	15	460	0
93	M	65	1.76	106.5	34.6	11.6	19.2	1843	3655	1813	366	1.98	99	8197	1883	63	1310	16
94	M	69	1.79	92.8	29.0	29.5	31.2	1748	3066	1318	307	1.75	99	8867	1213	7	818	0
95	F	66	1.52	63.7	27.8	9.2	9.6	1216	2449	1233	245	2.01	100	8493	1587	329	1032	143
96	F	52	1.63	110.9	41.7	3.8	20.9	1746	2642	896	264	1.51	98	9458	622	1	193	0
97	F	62	1.61	69.8	26.9			1305	2826	1521	283	2.17	99	8378	1702	618	1366	448
98	M	68	1.65	92.8	34.1	19.2	24.9	1612	2179	567	218	1.35	99	9710	370	3	144	0
99	M	68	1.65	55.9	20.5	24.0	6.1	1277	2100	824	210	1.65	96	9174	906	128	494	52
100	M	68	1.85	96.9	28.3	13.9	7.7	1843	2813	969	281	1.53	100	9491	589	29	423	0
101	M	68	1.86	108.2	31.4	20.7	15.7	1955	3210	1255	321	1.64	98	9581	499	0	165	0
102	F	69	1.63	66.3	25.0	10.6	12.1	1287	2024	737	202	1.57	99	9524	556	104	307	52
103	M	70	1.80	107.7	33.2	24.4	28.9	1893	3509	1617	351	1.85	99	8758	1322	57	923	0
104	F	71	1.53	53.5	22.9	10.6	6.2	1140	1678	538	168	1.47	98	9826	254	44	145	20
105	F	60	1.65	92.3	34.1	4.1	21.1	1595	2818	1223	282	1.77	99	8970	1110	19	625	0
106	M	65	1.74	77.9	25.7	11.8	6.2	1564	3674	2110	367	2.35	99	7631	2449	497	1943	151
107	F	71	1.64	66.4	24.8	11.9	4.3	1292	2658	1367	266	2.06	99	8440	1640	416	1159	190
108	M	69	1.77	74.4	23.9	15.6	7.8	1561	2696	1135	270	1.73	99	8942	1138	38	632	0
109	M	62	1.74	78.4	26.0	11.4	6.4	1568	3049	1480	305	1.94	99	8721	1359	163	960	27
110	M	58	1.80	102.0	31.7	8.0	11.7	2041	5023	2982	502	2.46	100	7140	2940	30	2390	0
111	F	56	1.64	80.2	30.0	11.9	16.9	1497	2325	828	232	1.55	99	9386	694	15	323	0
112	F	67	1.68	91.1	32.5	16.1	17.5	1505	2647	1142	265	1.76	99	9322	758	36	400	21
113	F	69	1.68	95.8	34.1	12.6	13.1	1542	2713	1172	271	1.76	100	9081	999	1	442	0
114	F	51	1.78	125.5	39.8	2.5	11.5	1865	3173	1308	317	1.70	99	9414	666	0	211	0
115	M	67	1.77	84.0	27.0	11.9	15.0	1648	2901	1253	290	1.76	98	8876	1204	57	791	0
116	M	70	1.76	84.9	27.4	32.6	13.9	1647	3118	1471	312	1.89	99	8713	1367	128	905	14
117	F	68	1.56	74.1	30.4	9.8	8.5	1316	2580	1264	258	1.96	100	8460	1621	169	948	0
118	M	64	1.78	86.2	27.2	11.7	7.0	1678	2978	1299	298	1.77	99	8922	1158	36	751	0
119	M	71	1.75	85.8	28.0	19.9	10.4	1645	2639	993	264	1.60	97	9493	587	21	212	0
120	F	67	1.66	54.1	19.6	20.5	1.9	1204	2036	831	204	1.69	100	9187	893	154	506	82
121	F	70	1.75	89.3	29.2	13.8	6.4	1523	2440	917	244	1.60	98	9439	641	7	290	0
122	M	57	1.87	108.6	31.1	9.5	10.7	2117	3380	1263	338	1.60	98	9479	601	0	257	0
123	M	66	1.82	96.6	29.2	32.6	13.0	1811	3059	1248	306	1.69	98	9280	800	50	548	18
124	M	70	1.72	90.4	30.6	31.6	19.6	1658	2846	1188	285	1.72	99	9161	919	46	520	0
125	F	61	1.54	82.2	34.6	8.2	27.7	1371	2009	639	201	1.47	98	9514	566	0	257	0
126	M	56	1.87	120.0	34.5	8.1	17.1	2247	4048	1800	405	1.80	99	8835	1245	0	786	0
127	M	62	1.79	94.2	29.6	22.0	10.9	1760	3173	1413	317	1.80	99	8727	1353	52	913	0
128	M	63	1.65	76.2	28.0	11.5	7.0	1461	2283	822	228	1.56	96	9278	802	49	578	0
129	M	66	1.83	91.8	27.4	15.4	11.7	1777	3073	1295	307	1.73	99	9183	897	8	500	0
130	F	65	1.56	79.6	32.7	10.2	10.9	1359	2312	953	231	1.70	99	9114	966	59	562	0
131	M	57	1.81	82.9	25.3	11.4	5.4	1822	3541	1719	354	1.94	99	8658	1422	176	752	0
132	F	67	1.54	84.0	35.7	11.3	17.3	1385	2108	723	211	1.52	99	9770	310	5	78	0

COMPARISON 2														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
133	M	68	1.62	81.4	31.2	25.0	14.8	1479	2387	908	239	1.61	99	9329	751	60	398	11
134	M	66	1.69	74.8	26.2	14.1	18.4	1487	2976	1489	298	2.00	100	8278	1802	190	1254	42
135	M	54	1.79	95.0	29.6	11.6	14.4	1961	3182	1221	318	1.62	99	9466	614	51	389	21
136	M	49	1.81	123.3	37.8	11.6	32.5	2285	3737	1452	374	1.64	100	9131	949	3	743	0
137	F	70	1.75	81.6	26.8	17.2	10.7	1462	2353	891	235	1.61	99	9300	780	66	535	0
138	M	48	1.81	85.4	26.1	9.5	4.2	1851	4420	2569	442	2.39	98	7212	2868	313	2563	58
139	F	66	1.65	57.0	20.9	10.4	2.3	1222	2045	823	205	1.67	99	9368	712	111	368	27
140	F	59	1.57	83.4	33.8	12.6	27.3	1523	2443	920	244	1.60	99	9273	807	86	458	22
141	F	70	1.49	58.6	26.4	14.3	5.0	1162	1876	715	188	1.62	99	9153	927	203	635	56
142	F	66	1.68	86.6	30.9	14.1	25.3	1469	2179	710	218	1.48	98	9538	542	15	366	0
143	F	58	1.53	76.9	33.1	4.1	18.6	1470	2150	680	215	1.46	99	9595	485	6	168	0
144	M	70	1.83	83.0	24.9	14.4	5.1	1698	2659	961	266	1.57	99	9526	554	117	310	70
145	M	68	1.66	75.2	27.3	18.6	11.4	1462	2210	748	221	1.51	99	9569	511	119	346	84
146	M	61	1.67	79.2	28.6	19.6	15.6	1508	2792	1284	279	1.85	98	8843	1237	51	730	13
147	M	69	1.90	117.8	32.8	19.3	21.1	2081	3575	1494	358	1.72	100	9276	804	3	425	0
148	M	68	1.73	85.8	28.7	18.6	12.9	1626	2384	758	238	1.47	98	9675	405	22	167	0
149	M	68	1.78	84.5	26.7	23.0	6.6	1662	3198	1536	320	1.92	99	8680	1400	208	951	24
150	F	69	1.53	84.0	35.7	16.1	44.7	1380	2125	745	213	1.54	99	9430	650	3	321	0
151	M	65	1.73	97.2	32.5	14.8	17.6	1729	3198	1469	320	1.85	98	8662	1418	76	1030	0
152	M	68	1.86	98.4	28.4	28.6	31.8	1867	3798	1931	380	2.03	99	8307	1773	101	1260	37
153	M	67	1.77	69.8	22.3	15.0	4.7	1519	2772	1253	277	1.82	99	8900	1180	232	810	55
154	F	67	1.55	67.4	28.2	13.2	6.8	1259	2853	1595	285	2.27	98	7992	2088	598	1514	187
155	F	43	1.67	107.7	38.8	3.4	20.2	1720	2549	829	255	1.48	99	9577	503	9	244	0
156	F	61	1.50	52.6	23.5	10.8	3.0	1119	1549	430	155	1.38	99	9782	298	21	101	0
157	M	67	1.83	97.3	29.2	17.2	9.5	1827	3389	1562	339	1.85	99	8629	1451	40	1050	0
158	F	70	1.65	62.9	23.2	12.2	2.8	1269	2430	1161	243	1.92	98	8661	1419	211	918	78
159	M	67	1.71	78.1	26.8	33.1	18.8	1537	2608	1071	261	1.70	98	9000	1080	98	879	28
160	F	63	1.64	84.3	31.3	11.4	12.1	1433	1927	494	193	1.34	98	9857	223	4	86	0
161	M	68	1.76	92.9	30.0	21.1	19.9	1719	2798	1079	280	1.63	98	9202	878	5	506	0
162	M	64	1.75	85.3	27.9	18.7	7.3	1641	2424	783	242	1.48	100	9603	477	3	208	0
163	M	61	1.86	92.9	26.8	19.9	6.8	1817	3446	1629	345	1.90	99	8984	1096	114	654	16
164	M	60	1.60	68.6	26.8	13.6	7.3	1343	3419	2076	342	2.55	96	7960	2120	473	1578	130
165	F	68	1.60	68.4	26.7	12.7	4.9	1289	2128	839	213	1.65	100	9304	776	33	478	0
166	F	45	1.73	99.2	33.2	2.3	13.8	1651	2982	1331	298	1.81	99	8611	1469	22	873	0
167	M	59	1.74	72.0	23.8	10.8	3.8	1697	2926	1228	293	1.72	99	9103	977	260	634	99
168	F	69	1.71	71.5	24.5	10.5	3.5	1364	2274	910	227	1.67	99	9442	638	59	280	0
169	F	56	1.58	93.3	37.3	5.1	25.6	1603	2349	746	235	1.47	98	9615	465	8	185	0
170	F	61	1.60	70.7	27.6	8.9	5.5	1308	2224	916	222	1.70	99	9315	765	94	350	14
171	M	64	1.79	92.3	28.7	13.1	19.3	1743	3234	1491	323	1.86	99	8685	1395	42	965	12
172	M	60	1.88	103.0	29.0	9.5	10.0	1928	3682	1755	368	1.91	99	8767	1313	20	759	0
173	M	68	1.80	89.4	27.5	13.5	8.3	1727	2935	1209	294	1.70	98	9224	856	67	496	53
174	M	48	1.77	116.2	37.1	3.6	31.1	2204	3165	961	317	1.44	100	9809	271	11	113	0
175	M	63	1.79	71.3	22.4	9.4	2.7	1553	2973	1421	297	1.92	100	8550	1530	142	1085	48
176	M	63	1.64	73.3	27.4	12.9	14.8	1420	2656	1236	266	1.87	95	8712	1369	193	819	30

COMPARISON 2														Physical activity			Activity bouts	
Count	Sex	Age	Height	Weight	BMI	QRisk	QDiabetes	RMR	TEE	AEE	DIT	PAL	On-body time	<3 METs	>3 METs	>6 METs	>3 METs	>6 METs
	M/F	y	m	kg	kg/m^2	%	%	kcal/day	kcal/day	kcal/day	kcal/day	ratio	%	mins/week	mins/week	mins/week	mins/week	mins/week
177	M	64	1.71	71.6	24.6	16.4	4.5	1478	2592	1115	259	1.75	100	9079	1001	171	626	28
178	M	69	1.74	91.0	29.9	34.1	19.2	1683	2977	1294	298	1.77	98	8983	1097	18	463	11
179	M	59	1.78	75.9	24.0	11.0	3.8	1742	3187	1445	319	1.83	99	8700	1380	74	913	11
180	F	66	1.67	74.5	26.7	14.4	6.1	1370	2103	734	210	1.54	99	9665	415	84	242	0
181	F	49	1.64	97.0	36.2	1.3	17.9	1866	2979	1113	298	1.60	99	9454	626	3	265	0
182	M	67	1.76	100.4	32.5	25.4	27.1	1787	3284	1497	328	1.84	99	8762	1318	3	785	0
183	M	46	1.72	95.7	32.3	8.1	20.2	1969	3010	1041	301	1.53	100	9421	659	1	364	0
184	F	67	1.53	49.2	21.0	13.2	3.8	1106	1692	586	169	1.53	87	9539	541	67	309	0
185	M	61	1.80	111.3	34.4	12.5	22.9	1925	3268	1342	327	1.70	99	8941	1139	2	668	0
186	F	59	1.63	106.2	40.2	6.9	15.7	1708	2326	618	233	1.36	98	9694	386	0	184	0
187	M	53	1.70	73.2	25.3	9.6	8.0	1711	2641	930	264	1.54	99	9552	528	42	242	0
188	M	69	1.83	86.0	25.6	17.2	5.3	1725	2427	702	243	1.41	99	9861	219	3	79	0
189	M	70	1.79	99.0	31.1	18.5	18.7	1804	3510	1706	351	1.95	99	8625	1455	151	1079	10
190	M	69	1.73	74.9	25.1	14.8	5.2	1525	2336	811	234	1.53	99	9490	590	21	350	0
191	M	62	1.72	79.3	26.8	16.4	7.1	1557	2409	852	241	1.55	99	9593	487	53	295	25
192	M	49	1.67	89.6	32.1	6.7	23.2	1899	3420	1520	342	1.80	99	8638	1442	27	909	0
193	F	70	1.58	62.6	25.1	12.5	4.3	1235	2376	1141	238	1.92	99	8747	1333	349	873	69
194	M	62	1.73	89.0	29.6	13.3	16.3	1659	2800	1141	280	1.69	99	9043	1037	61	752	0
195	M	57	1.81	89.8	27.4	14.0	10.3	1901	3124	1222	312	1.64	100	9270	810	78	536	15
196	M	68	1.93	106.1	28.6	17.5	15.1	2000	3384	1384	338	1.69	97	9167	913	17	584	10
197	M	67	1.77	90.3	28.8	22.7	10.0	1706	3163	1458	316	1.85	99	8573	1507	114	996	99
198	M	66	1.85	88.1	25.9	16.7	5.9	1758	2961	1202	296	1.68	99	9321	759	33	352	0
199	M	59	1.68	77.6	27.5	6.9	6.5	1762	2704	943	270	1.54	94	9435	645	67	349	11
200	F	68	1.55	88.0	36.9	12.9	15.6	1421	2100	679	210	1.48	99	9507	573	7	295	0
201	F	68	1.69	66.9	23.4	11.2	5.4	1319	2374	1056	237	1.80	100	8915	1165	168	731	35
202	F	65	1.56	70.3	29.1	10.0	11.2	1284	2082	798	208	1.62	100	9270	810	84	476	0
203	M	64	1.84	68.2	20.3	10.5	1.8	1568	2855	1287	285	1.82	98	8956	1124	167	784	53
204	M	59	1.73	87.0	29.0	10.5	13.4	1870	3295	1425	329	1.76	98	9088	992	152	606	73
	Mean	64	1.71	84.4	28.7	14.2	12.7	1609	2845	1236	284	1.77	99	8990	1090	109	715	34
	SD	6	0.09	15.0	4.5	6.4	9.1	243	587	436	59	0.25	1	571	571	148	489	74
	Min	43	1.49	49.2	19.6	1.3	1.8	1106	1549	430	155	1.34	87	7140	219	0	78	0
	Max	71	1.98	125.5	43.1	34.1	76.1	2285	5023	2982	502	2.55	100	9861	2940	808	2563	542

Additional File 3

ANALYSIS OF PHYSICAL ACTIVITY IN BOUTS OF 10 MINUTES

Introduction and Methods

Some physical activity recommendations refer to the requirement to accumulate physical activity in bouts of 10 minutes or more. The 10-minute bout is largely arbitrary and smaller bouts are demonstrably important for health. Furthermore, a focus on bouts also introduces the problem of how to define what is meant by a bout. For example, three consecutive 8-minute blocks of sustained activity with a 2-3 minute gap in between each block might not count towards a bout-based metric but a single 10-minute block would. Of course, the issue of how to factor in any baseline normal lifestyle physical activity still remains even if physical activity is analysed in bouts. However, given the prominence of bouts in some recommendations, we used in-house software to examine the number of minutes engaged in physical activity above 3 METs in bouts of at least 10 minutes.

Results

On average, participants undertook 287 ± 209 and 715 ± 489 minutes of moderate-to-vigorous intensity physical activity in bouts of 10 minutes or more in Comparisons 1 and 2, respectively. Based on this analysis, a PAL of 1.75 equates to 292 minutes (Comparison 1) and 683 minutes (Comparison 2) of moderate-to-vigorous intensity physical activity (Figure 1S). A caveat here is that the residuals for Comparison 1, in particular, are not well behaved, suggesting problems with the specification of the simple linear model. Re-specification of the model as a power function of the form $Y=aX^b$ improved the fit but made no material difference to the estimate.

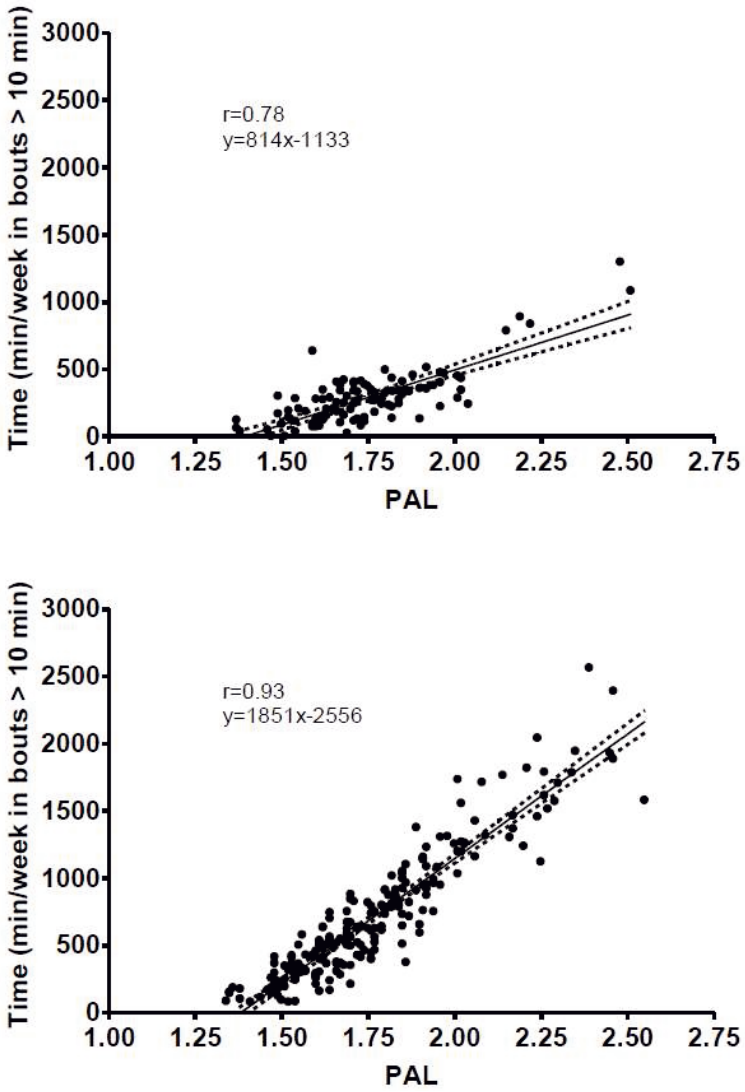

Figure 1S: The relationship between PAL as a standardised measure of physical activity energy expenditure (TEE/BMR) and moderate-to-vigorous intensity physical activity in bouts of 10 minutes or more. Panel A shows the research instrument used in Comparison 1 (n=101) and Panel B the commercial instrument used in Comparison 2 (n=204). The regression line with 95% CI are included.

Discussion

As highlighted in the primary discussion, an analysis of physical activity in bouts of 10 minutes is arbitrary and problematic. Nonetheless, it is noteworthy that even in this analysis most participants exceeded weekly physical activity recommendations after taking bouts into consideration. These results are affected by the same issue of how to factor in baseline physical activity (i.e., normal lifestyle activities). According to this analysis, a PAL of 1.75 equates to approximately 2-5 fold the recommendation. It is noteworthy that there was a bigger difference between devices for this bout-related analysis. Although the reason for this is not fully clear, it is likely to be related to the variability (and limitations) of the different types of physiological sensors used in these devices. For example, an unresolved issue with temperature and heat flux sensing (as used in the BodyMedia FIT device) is the lag time to dissipate heat from the body upon completing moderate-to-vigorous intensity activity [1]. This could conceivably ‘extend’ a given bout or mask short gaps between more fragmented activities. As is the case for many commercial

instruments, the algorithms used in the BodyMedia device are proprietary and thus it is difficult to determine if this consideration is a main cause of the reported difference. An alternative explanation is that sample-specific differences (e.g., age) could mean that differences in the pattern and nature of activity between comparisons could affect bout-related scores. Whatever the explanation, this does not affect the overall conclusion that an analysis of activity even after factoring in bouts will not be compatible with widely disseminated physical activity recommendations. As stated in the primary discussion, this analysis seems less relevant for the future because so few commercial monitors provide feedback in the form of bouts and many agencies omit bouts in their dissemination of physical activity guidance.

References

Chen, K.Y., et al., *Redefining the roles of sensors in objective physical activity monitoring.* Med Sci Sports Exerc, 2012. **44**(1 Suppl 1): p. S13-23.